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The Ingestion of Asbestos Fibers

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Feeding of baboons with crocidolite showed small numbers of asbestos needles 0.5–1 μm in ashed tissue of the gut wall, which probably came from iron-containing macrophages. It is suggested that pleural plaques and hyaline nodules in the peritoneum represent a hypersensitivity reaction to ferritin protein coating on asbestos fibers. In South Africa only a few peritoneal mesotheliomas come from the asbestos areas, and the incidence of gastrointestinal carcinomas is no greater than normal. Intrapleural and intraperitoneal injection produces unrealistic situations.

Calcium salts are deposited on asbestos cement pipes from hard water and organic material from soft water. It is difficult to envisage asbestos contamination of the water so reticulated.

In our laboratories the baboons are not on pellet feeding and have eaten food and drunk water contaminated with asbestos during the experimental period which in some instances has been to heavy concentrations of asbestos for up to 5 years. No macroscopic lesion has been found in the abdominal cavity or any evidence of abnormality which would warrant taking any more than the usual histological blocks. Examination of the feces suggested the presence of an occasional asbestos needle. In none of the many baboons used was there any evidence of a peritoneal tumor or gastrointestinal tumor.

As a pilot experiment a baboon was given 200 mg of crocidolite asbestos into the stomach through a gastric tube at 10.00 a.m. on a Friday. At 5:00 p.m. that day asbestos needles were found in the feces with ease and similarly on subsequent days. At autopsy on the following Monday afternoon, 3:00 p.m., asbestos needles were only found in the lower part of the pelvic colon.

Histological examination of the stomach and intestinal tract showed the presence of macrophages containing iron particles in the mucosa of the duodenum and the upper ileum (Fig. 1). There was no evidence of asbestos needles in the sections of the mucosa or the serosal surface on histological examination of sections incinerated in the low temperature asher. Only an occasional asbestos needle was found on the examination of the ashed tissue of

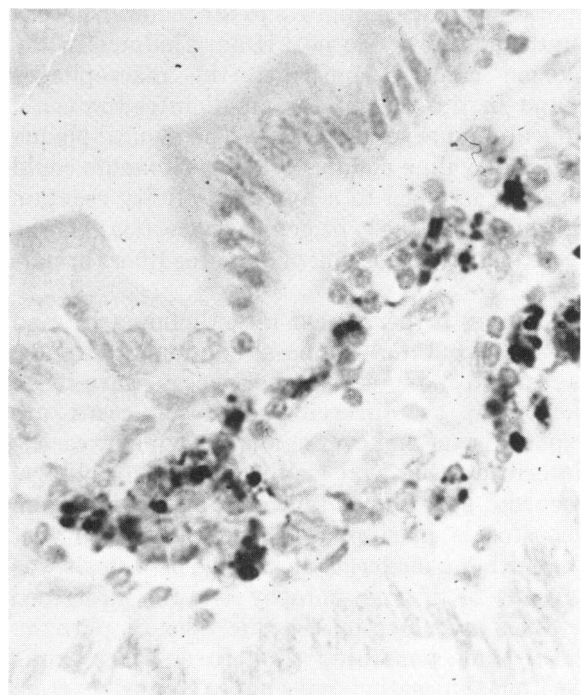

FIGURE 1. Macrophages in jejunum.

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the stomach, and it was considered that this fiber could have been associated with the ashed material because of its presence in the lumen of the gut.

On electron microscopy, the ashed tissue showed numbers of small asbestos needles 0.5 – 1 μm which in all probability came from the iron containing macrophages. X-ray diffraction confirmed that the fibers were asbestos and the electron probe proved that the iron was not hemosiderin.

Of interest is the presence of nodular hyaline fibrosis of the peritoneum preceding the development of a mesothelioma. This finding places the pathogenesis of mesothelioma of the peritoneum and pleura on the same basis, which is most satisfying to pathologists. The nodular hyaline fibrosis of the peritoneum can be equated to the noncalcified pleural plaque from which some of us consider the mesothelioma develops.

The alveolar macrophages containing fine asbestos particles migrate to the pleura whereas the longer fibers do not. If our findings in the baboon can be confirmed the macrophages found in the villi of the small intestine could migrate to the serosal tissue. The pleural plaque and the hyaline nodules of the peritoneum could both be ascribed to a hypersensitivity reaction initiated by the antigenic properties of the ferritin protein coating of asbestos fibers or particles.

Turning to peritoneal mesothelioma in man for a moment and—in passing I doubt if anyone is certain how many such cases have been described, as different series of cases are reported over and over again as each new case is described—that as it may looking at the clinical records and the industrial exposure when asbestos is incriminated, the records suggest that either a moderate or marked asbestosis was present or if any autopsy is fully described nodules are noted on the thickened diaphragm. Is it not possible, therefore, that some peritoneal mesotheliomas have their origin from diaphragmatic plaques which have nothing to do with the ingestion of asbestos fibers?

If one is to postulate that the ingestion of the fibers is associated with the development of gastrointestinal carcinoma and peritoneal mesothelioma, some evidence of such an association should be found in the asbestos areas of South Africa.

Whereas there are some 450 pleural mesothelial tumors in the South African Asbestos Tumour Reference Panel Register, there are only 24 peritoneal mesotheliomas, and in earlier days one was impressed with the numbers of cases of peritoneal mesothelioma being reported in the United Kingdom when so few were to be found in South Africa (Table 1). Such tumors would be referred to hospitals in the Cape Province, the South African Institute for Medical Research. Discussion with the pathologists of the Cape Provincial Hospitals have given me to understand that only a few periotheliomas come from the asbestos areas and there does not appear to be a higher than expected incidence of gastrointestinal carcinomas from these, the asbestos areas. It will be interesting to hear what the comparative incidence figures are for different parts of South Africa as found by the National Cancer Association.

Table 1. Peritoneal mesotheliom in South Africa.

Diagnosis	No.
Laparotomy	12
Biopsy + autopsy	1
Autopsy	6
Asbestosis	6
No information	4

Table 2. Exposure in cases of peritoneal mesothelioma.

Asbestos exposure	No.
Cape crocidolite	9
Mixed	1
Not specified	1
Doubtful	1
	1
Total	12

We are particularly interested in determining why asbestos cement dust produces a greater degree of cellular metaplasia than asbestos alone after the same exposure. This experimental pathology has led us into the field of water research, and as possible contamination of drinking water by asbestos fibers is pertinent to the subject of this conference I will digress from the purely experimental pathology and show what we have found.

South Africa is a country which is indeed water conscious, and as there are areas with a low rainfall which are often drought—stricken large water conservation schemes have been in-

troduced or are under construction. In order to prevent corrosion of steel and incidentally of asbestos—cement pipes, calcium carbonate is added to our water to bring the pH into the region of 9 giving a positive saturation index.

In pipes carrying hard water (with a positive saturation index) the asbestos-cement pipe shows little change even after many years (Fig. 2). Even with a negative saturation index as in soft water there is little damage to the asbestos-cement pipe and organic material is deposited on the inner surface (Fig. 3). With high satura-

FIGURE 2. Asbestos-cement pipe, hard water; Rand Water Board.

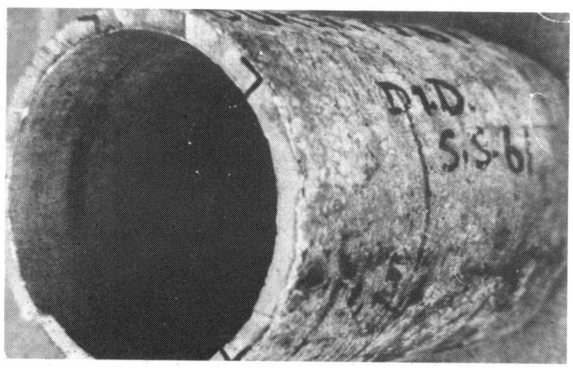

FIGURE 3. Asbestos-cement pipe; soft water; Stellenbosch, 20 years.

tion indices there is well marked deposition of calcium salts lining the inside of the pipe as shown by a pipe which was carrying brine near the Koegas mine or salt at one of the asbestos cement factories (Figs. 4 and 5). It is, therefore, difficult to envisage asbestos contamination of drinking water which is hard and reticulated through asbestos-cement pipes.

Sewage, however, is acid and will corrode the asbestos-cement pipes due to the release of carbon dioxide and the formation of sulfuric acid through bacterial action (Figs. 6 and 7). Now that such water is being treated and used for industrial purposes there are many investigations underway to determine whether the water is fit for human consumption. It is unlikely that asbestos fibers will be found but should such be the finding the introduction of a flocculating

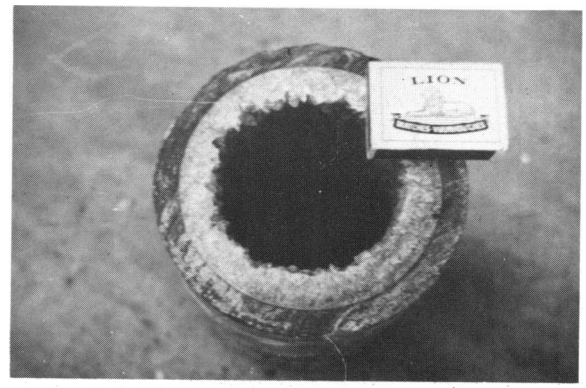

FIGURE 4. Asbestos-cement; brine near Koegas.

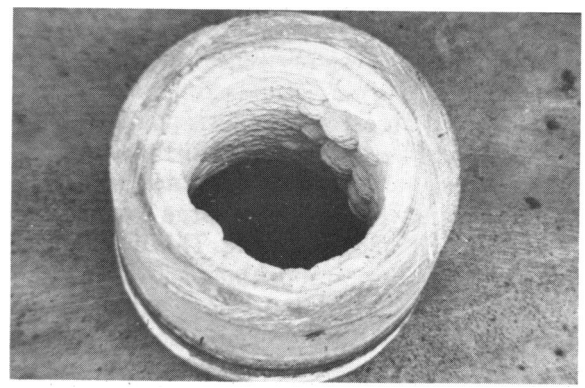

FIGURE 5. Asbestos-cement, calcium chloride; Asbestos Cement Plant.

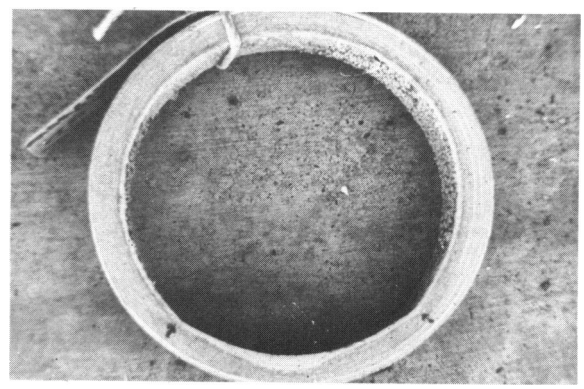

FIGURE 6. Asbestos-cement sewerage pipe; Port Elizabeth, 19 years.

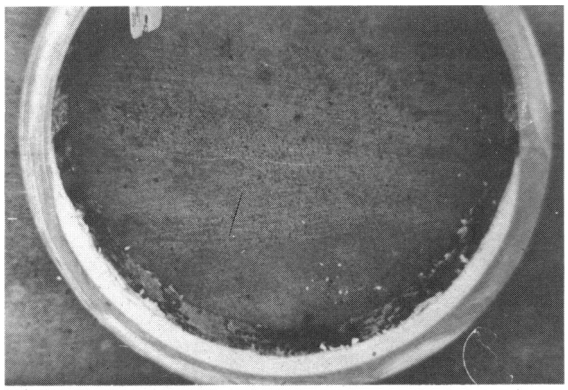

FIGURE 7. Asbestos cement sewerage pipe; Walvis Bay, 11 years.

filtration system will prevent fiber contamination.

I have digressed from the experimental pathology of the biological aspects of ingested asbestos, but the water situation in South Africa may well explain why in the large asbestos mining areas peritoneal mesothelioma and probably gastrointestinal carcinoma are not found to such an extent as they apparently are in other countries. Even the Kuruman area is supplied to a large extent by water from the Kuruman Eye which releases large amounts of water from the dolomite strata. This is probably the reason for the establishment of Kuruman.

It must be recorded and I hope remembered that in the use of the direct inoculation of substances into the peritoneal or pleural cavities an artificial situation is created. These cavities are lined by a mesothelial layer which reacts in a hyperplastic manner to many different stimuli. We know of silica producing mesotheliomata, of glass fiber of the MC29 avian leukosis virus *(1)* which will do the same. We know that millions of peritoneal cells can be produced into the peritoneal cavity by stimulants such as glycogen, oils and even Hanks solution. Have any of us kept animals alive after such stimulation? Will a mesothelioma develop later? Mesothelioma has followed repeated induction of pneumoperitonium.

In summary then, animal experimentation only partly supports the epidemiological studies showing an increased incidence of intestinal carcinoma. Such support can only be given on the basis that the carcinogenic factor associated with asbestos is the property of the fine asbestos particles and not the longer asbestos fibers as these do not appear to pass from the lumen of the gut to the serosal surface.

It is difficult to support the increased incidence of gastric carcinoma as there was no evidence of asbestos particles or needles in the mucous membrane of the stomach.

It must be appreciated that to most of us the biological effects of ingested asbestos is a new field of our research activities — a field in which I hope we will make more use of the normal route of entry of asbestos into the body without clouding the issue by intraperitoneal inoculation as we have done with the intrapleural experiments.

Let us remember too that while it is difficult to keep all asbestos out of the atmosphere we breathe it is possible and practical to keep it out of the water we drink.

REFERENCE

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